3.2 FACILITY DESCRIPTION

LANSCE (previously LAMPF) is a particle-accelerator-based research facility at Technical Area (TA-) 53 in Los Alamos National Laboratory. This SAD covers LANSCE beam-delivery operation and areas, including the linear accelerator (linac) and support buildings, beam use areas Area A/Area A-East at the east end, beamlines X-B-C and Areas B and C on the north side, and the Line D neutron science areas on the south side.

3.2.1 Facility Layout

Figure 3-8 gives a plan view of the site with the principal LANSCE buildings identified. Building number prefixes are “MPF-” (“Meson Physics Facility”) or “53-”. LANSCE (see also Table 3-1) comprises the following major operational sectors:

- Injector area, linac, and beam switchyard in MPF-3 Sectors J, A-H, and S;
- CCR, the Central Control Room beam operations, in MPF-4;
- Line A, Experimental Area A–A East in MPF 3 Sector M;
- Line X, Lines B and C; Areas B and C in MPF-3 Sectors N and P;
- Line D, the beamline leading south to the PSR, WNR, and MLNSC;
- The Proton Storage Ring (PSR) in MPF-8;
- The MLNSC Target and Experimental Rooms 1 (MPF-7) and 2 (MPF-30);
- The WNR targets and experimental areas in the MPF-7 complex.

Buildings associated with beam delivery and operational support also include MPF-2 and -17 with heavy shops, various building attached to the the numbered MPFs above, and several small or temporary buildings housing equipment. Other site structures include electric power distribution modules and cooling towers. AOT-FM, the site Facility Management office, maintains a list of buildings and owners. A site map book is available.

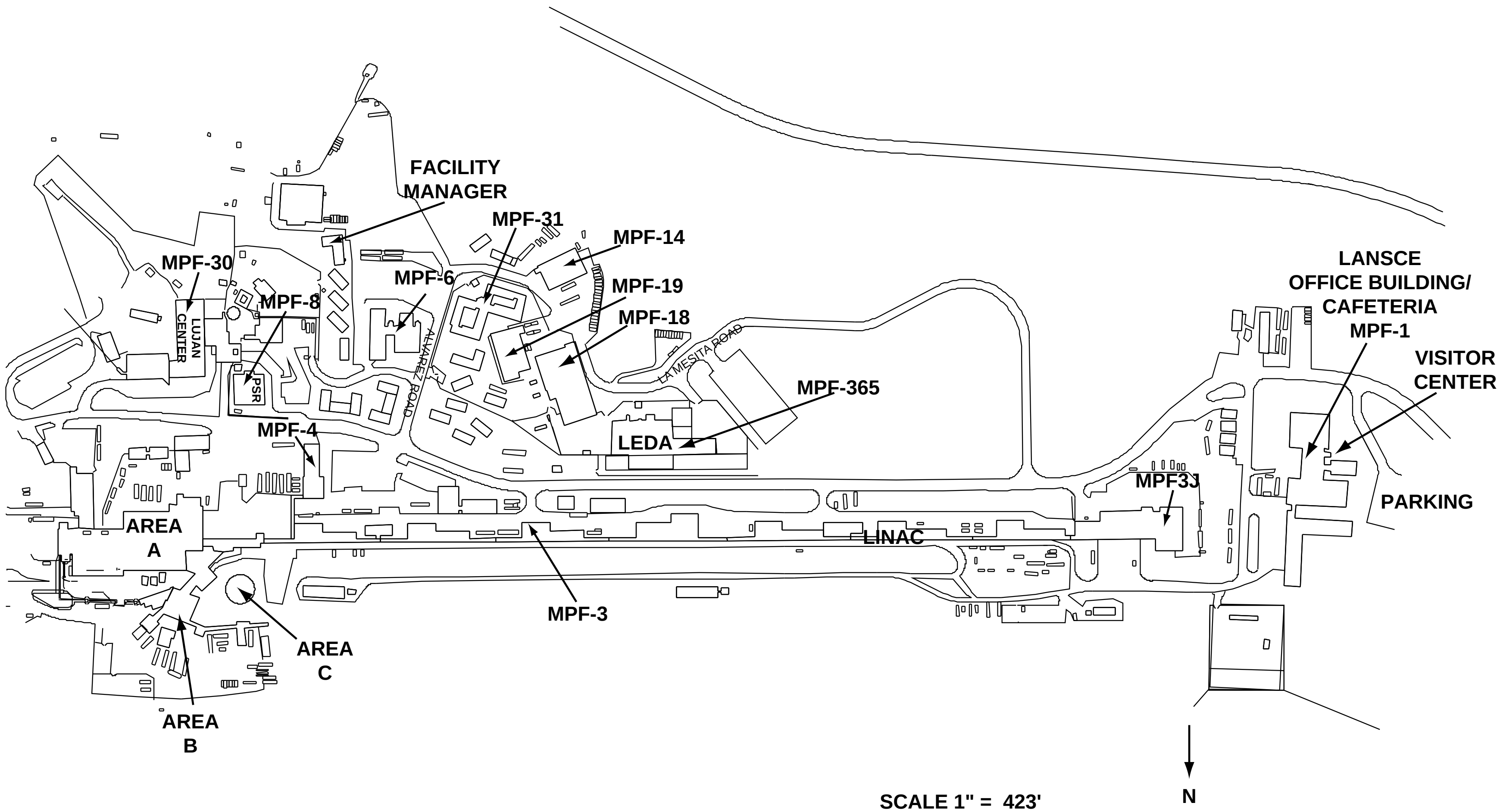

Figure 3-8. Plan view of LANSCE.

Table 3-1. Principle LANSCE buildings and areas.

Name	TA-53 (MPF-) Building No.	Description
Central Control Room (CCR)	MPF-4	Accelerator control room, Operations group offices and laboratory building
linac injector	MPF-3, Sector J	Houses beam injectors & low-energy transport
Drift-tube linac (DTL) and TR	MPF-3, Sector A	Accelerates beams to 100 MeV and prepares beams for SCL in Transition Region
Side-coupled linac (SCL)	MPF-3, Sectors B–H	Accelerates beams to 800 MeV. Linac tunnel is underground, below service aisle tunnel.
Switchyard (SY)	MPF-3, Sector S	Beam separation & transport to Lines A, X, D.
Lines X, B, C	MPF-3	Beam transport to Areas B and C.
Areas B, C	MPF-3 Sectors N, P	Area B contains the BR neutron channel, Area C is proton experimental area
Line A	MPF-3 Sectors S, M	Beamline from SY thru Area A
Area A	MPF-3M	“Meson” experimental area; targets A1, A2
Area A-East	MPF-3M	“Staging Area” and A6 beamstop facilities
ISORAD	MPF-3 Sector M east end	A6 isotope production and radiation effects facil.
Line D	MPF-7	Beamline to PSR, WNR, and MLNSC.
Proton Storage Ring (PSR) and Line D distribution	MPF-8 (PSR), MPF-28 (Ring Equipment Building)	PSR time-compresses the linac beam pulse. Interconnected beamlines serve MLNSC and WNR.
Weapons Neutron Research (WNR)	MPF-7 complex and Mechanical Equip. Bldg.	Beamline 1R, Target 2 & Blue Room, Target 4, neutron experimental facilities
Manuel Lujan Jr Neutron Scattering Center (MLNSC)	MPF-7 (ER-1), MPF-30 (ER-2), MPF-622 office building, other buildings	Beamline 1L, Target 1, ER-1, ER-2, neutron lines, equipment and support buildings
Equipment Test Laboratory (ETL)	MPF-2	Heavy mechanical shops, rf test stands, hydrogen brazing furnace
PSR Staging Building	MPF-17	Mechanical & electrical shops

3.2.2 Accelerator Systems

The accelerator system includes the injectors, the 100-MeV Drift Tube Linac (DTL), the Side-Coupled Linac (SCL), the Beam Switchyard (SY), and supporting systems.
Sector J houses three injectors. Injector A provides a proton (H^+) beam routinely used up to 30 mA peak. Injector B provides a negative hydrogen ion beam (H^-) of up to about 16 mAp. Injector C (inactive) provided a polarized negative hydrogen ion beam (“P^-”) of up to about 30 μAp. Each injector includes a preaccelerating system so that the beams fed to the linac have 750 keV energy. The injector gating and beam deflecting and chopping systems impose the correct time structure on the beams fed to the linac. The timing of beams entering the linac, the timing of the accelerator rf power pulses, and time distribution of the accelerated beam are synchronized by the Master Timer in the Central Control Room.

Supporting systems include utilities (electric power , natural gas, water, and waste-water), dc and rf power systems, and internal utilities—HVAC (heating, ventilation, and air conditioning], equipment cooling systems, compressed air, process water, etc. Figure 3-9 shows the main beam lines through the experimental areas and their relation to the linac. All beams from the linac enter the switchyard, where H^+ and H^- beams are magnetically separated (or for tuneup can be sent straight ahead to the switchyard beamstop). The H^+ beam is restored to a trajectory collinear with the linac and goes through Area A to the Line A beamstop. A switching magnet sends H^-beam down either Line X or Line D. The H^- beam in Line D is multiplexed: a pulsed switching magnet synchronized with the injector chopper normally sends high-intensity H^-pulses to PSR-MLNSC and heavily-chopped low-intensity pulses to WNR, although other combinations are possible by timing changes or reconfiguring equipment. In Line X, H^- (or P^-) beam can be stripped to H^+ and directed down Line C; the stripping fraction is completely adjustable. The remaining part of the beam continues down Line B.

3.2.3 Experimental Areas

The beam from the linac can be delivered to Area A, where secondary charged particle beams are available and the Isotope Production, Radiation Effects, and Neutrino facilities are used; to the Manuel Lujan Jr Los Alamos Neutron Scattering Center where thermal neutron secondary beams are available; to the Weapons Neutron Research Facility where the primary proton beam and secondary broadband neutron beams are available; to Line B and Area C where the primary proton beam is available, and to Area B where an energetic neutron beam can be made.

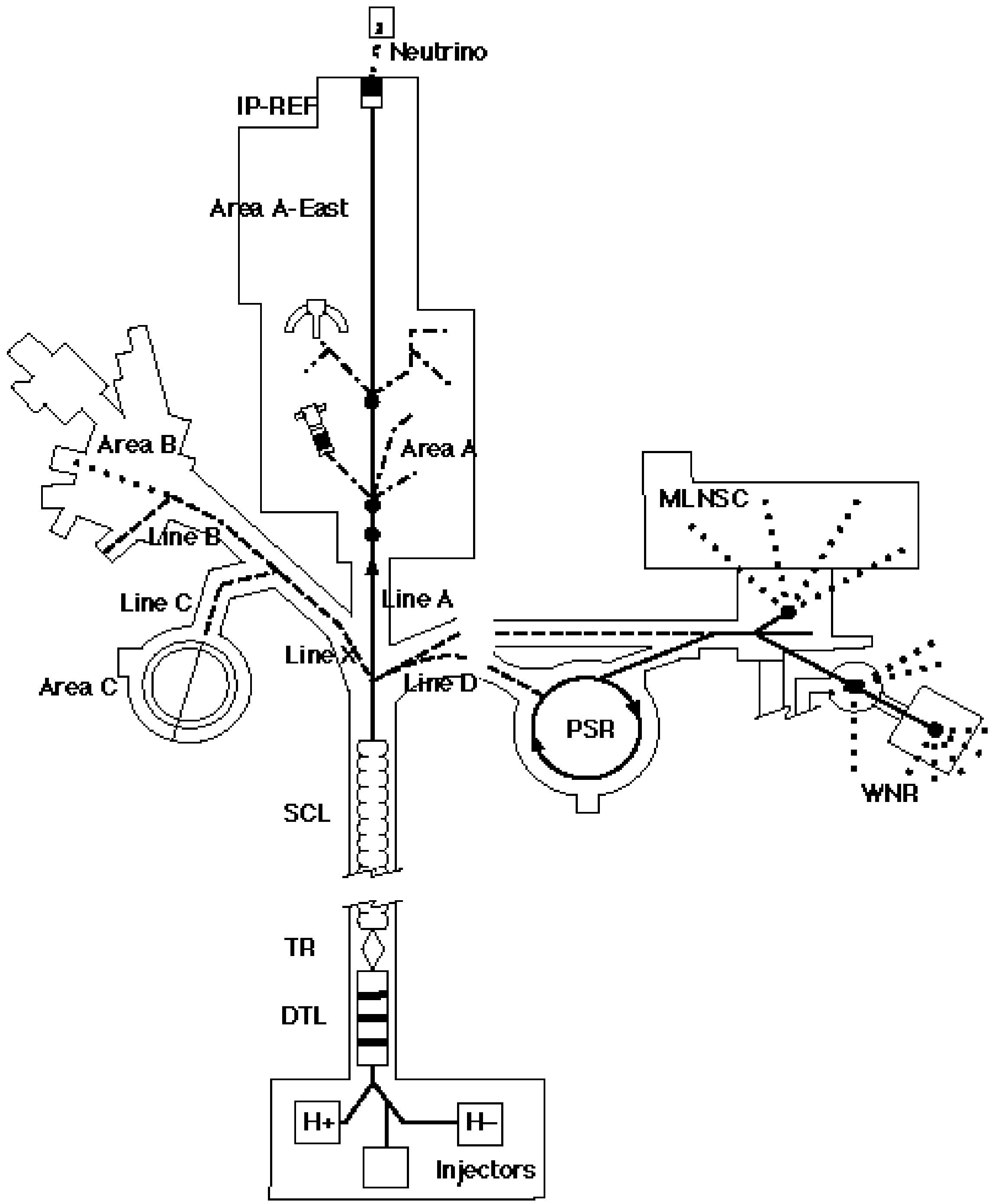

Figure 3-9. Schematic showing beamlines and major facilities.

3.2.3.1 Area A and Area A-East

The beam in Area A (Figure 3-10) goes through the A-1 and A-2 target stations, leaves the beamline vacuum pipe through the A6 window, passes through the A6 water target station, the proton irradiation station, the isotope production station, and the remainder is absorbed in the A6 beamstop. Use of targets in any of the five stations in any combination is possible.

The secondary particle beams in Area A are used to study nuclear structure, elementary particles, materials science, and for practical applications. In 1996, the DOE-OHENP-funded nuclear physics research program in Area A was largely discontinued and area utilization is low; however, operation of all of these facilities is covered in this SAD.

Target A-1 contains the production target (a rotating carbon wheel) for the secondary beam lines at the Energetic Pion Channel and Spectrometer (EPICS) and the Low-Energy Pion line (LEP). The A-1 target also produces a test beam that is delivered to a small cave next to LEP. About 90% of the H^+ beam is transmitted through Target A-1, and continues to Target A-2. Target A-2 contains the production target (also a rotating carbon wheel) for the secondary beam lines at the Stopped Muon Channel (SMC) and Pion and Particle Physics (P^3) channel. The A-2 target transmission is in the range of 80%.

Area A-East houses the beamstop area facilities, including the Isotope Production, Radiation Effects, and some experimental facilities (the Isotope Production–Radiation Effects combination is referred to in some documents as ISORAD or IP-REF). Of the original H^+ beam, anywhere from 20%–100% can reach the A-6 beamstop, a water-cooled copper cylinder, depending upon the upstream targets in place.

The Isotope Production Facility (IP) has nine stringers (long insertable sample holders) that are available for producing radionuclides, including medical isotopes. The parent material is held in a water-cooled holder on the end of the stringer, inserted horizontally on the stringer through a slot in the shielding so that the target is in position to intercept the proton beam, irradiated for a scheduled period, and then transferred to a shielded cask. The target is then taken to LANL hot-cell facilities outside of TA-53 for chemical processing. This SAD covers IP-REF beam operation but does not consider post-irradiation treatment of the materials.

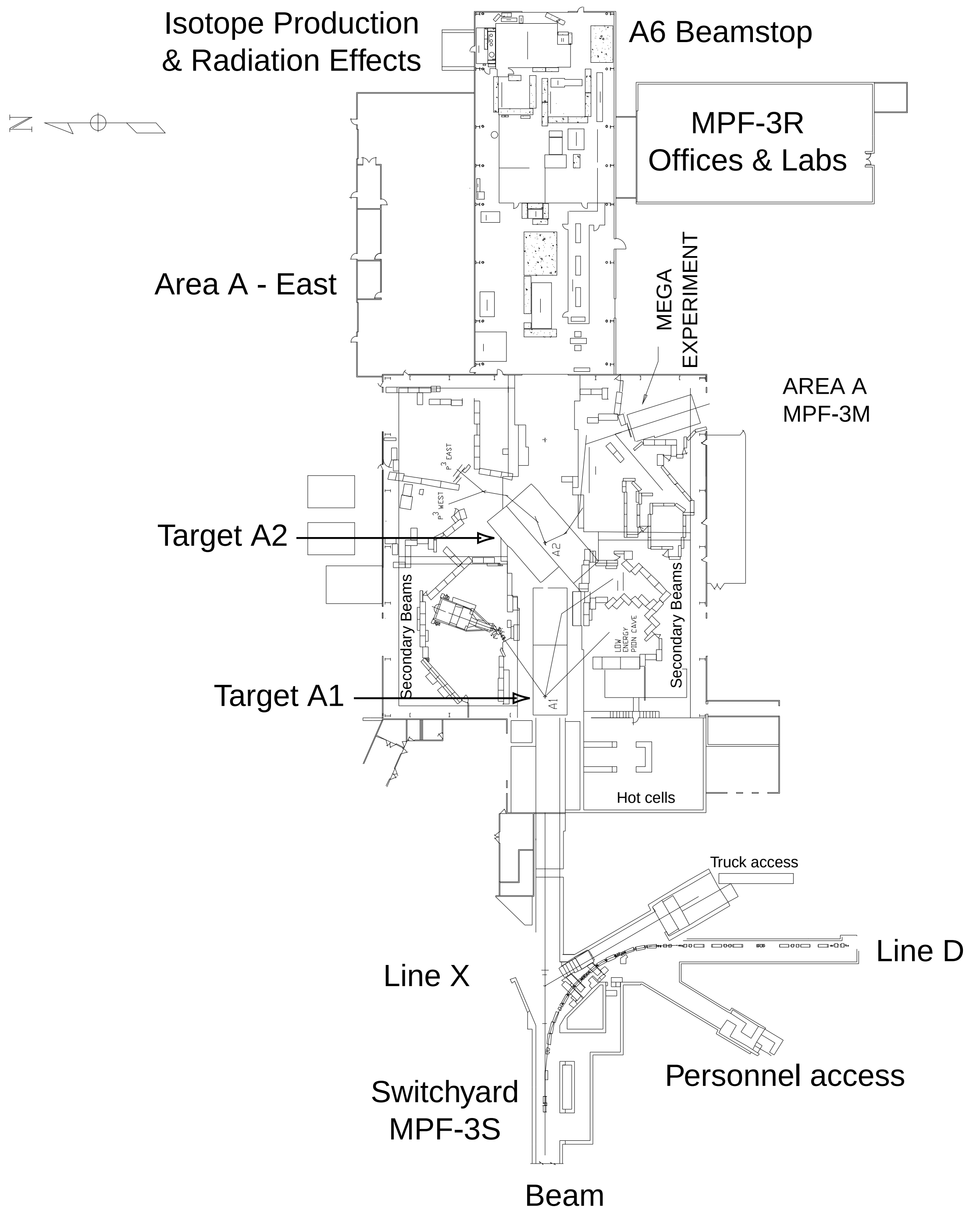

Figure 3-10. Beam switchyard and Area A.

At the Radiation Effects Facility (REF), material samples mounted on stringers can be inserted vertically into the main proton beam. Other inserts allow materials to be inserted into the shielding near the beamstop for neutron irradiation. The facility is used for study of materials under high radiation. The REF station is just upstream of the IP station.

The Liquid Scintillator Neutrino Detector (LSND) is a little over 20 m east of the A-6 beam stop. A short tunnel or cave provides shielding for the detector; there is about 22 m of compacted earth and a few inches of steel shielding between the beam stop and the detector, and shielding overhead and on the sides.

LANSCE high-intensity beams can induce high levels of radioactivity in beam targets, beamstops, and nearby equipment. To facilitate safe maintenance of these components, remote handling systems are used in Area A. These systems, called Monitors, use a pair of slave manipulators mounted on the boom of a portable hydraulic crane positioned at the work location (Grisham 1983). Operations are conducted from a master control station, installed in a trailer located a safe distance from the radioactive work area. Viewing is by closed-circuit television. For heavy lifting, remotely-controlled overhead bridge cranes are used.

3.2.3.2 Lines X, B, C; Areas B and C

Line X delivers beam to Line C–Area C and Line B–Area B, both usable for experimental setups at low to medium beam intensity. Area C, shown in Figure 3-11, is a circular room with a 14-meter-radius dome covered with 5 to 6 meters of earth for shielding and presently contains the inactive high-resolution proton spectrometer (HRS).

Line B delivers proton beam through the heavily-shielded end of Area B. A target can be inserted into the proton beam to produce neutrons that are extracted into the BR channel, while the protons are magnetically steered to the Line B beamstop. The neutron port is straight ahead with respect to the proton beam. A permanent magnet at the front of the neutron channel, inside the shielding vault, provides secondary protection against charged particles continuing down the neutron line. Alternatively, the proton beam can be targeted and stopped in the Line B tunnel, also a heavily-shielded area. Future use and configuration of the BR neutron channel is indeterminate at this point.

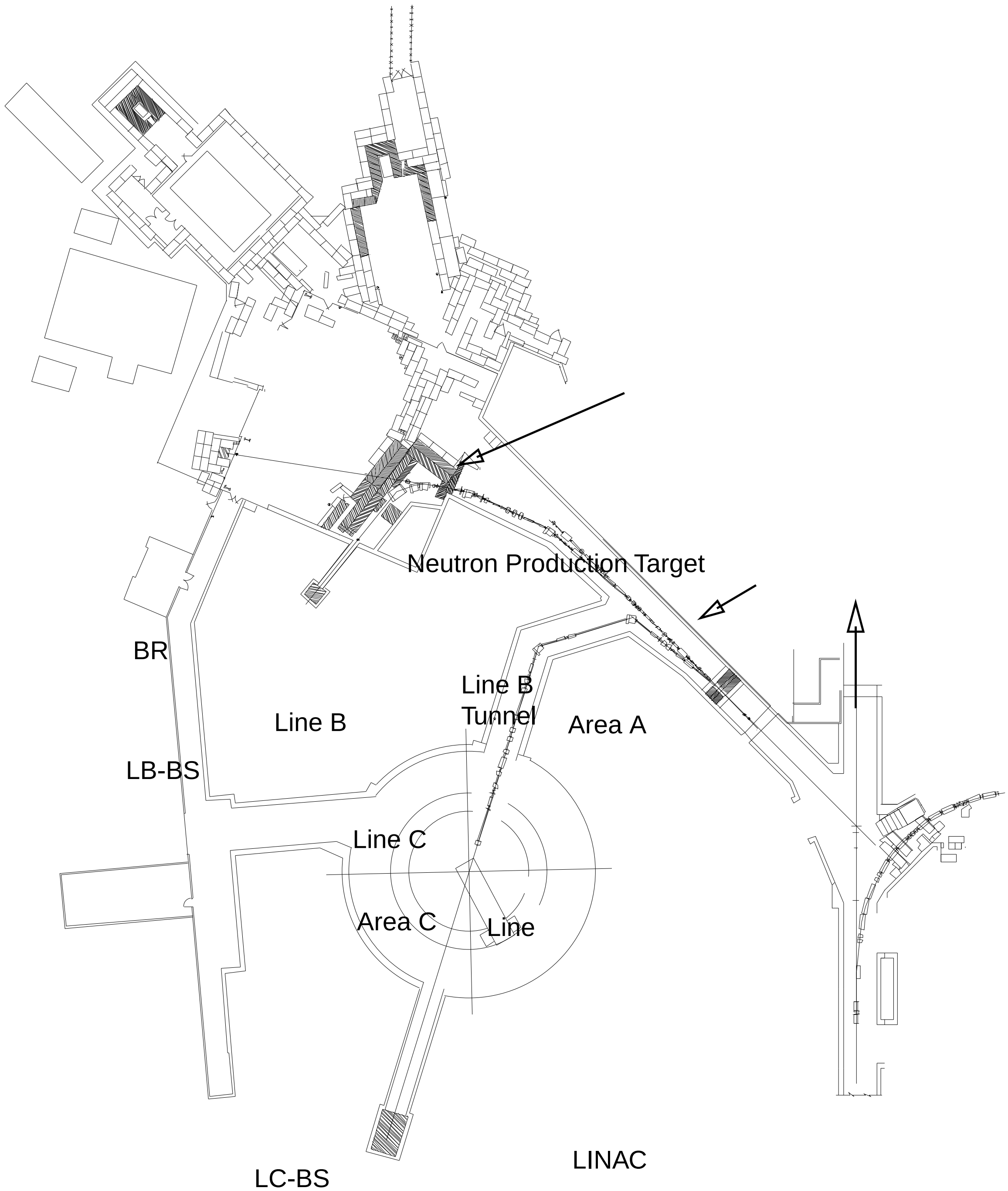

Figure 3-11. Plan view of Line B and Area C.

3.2.3.3 MLNSC and WNR

The WNR and MLNSC facilities receive beam from Line D. These facilities are shown in Figs. 3-12 and 3-13 and consist of the following major elements:

- Line D, the beamline leading south from the switchyard and housed in an underground tunnel and various branches to the facilities below;
- PSR, the Proton Storage Ring, a beam accumulator ring housed in an underground tunnel;
- MLNSC, including Line D Target 1 on branch 1L for neutron production and Experimental Rooms 1 and 2 (ER-1/2);
- WNR, including Line D Target 2 on branch 1R—a general purpose proton experimental area—and Target 4, a broadband neutron source, and their experimental facilities.

The illustrations show plan and perspective views of the Line D layout, a complicated three-dimensional geometry. The Line D, 1L, and 1R beam tunnels are included in the original WNR complex of buildings known as MPF-7. Other areas within MPF-7 are MLNSC Target 1 and ER-1, the Target 1 Service Cell and Service Area, Target 2, the WNR data acquisition rooms, and the WNR (Mechanical) Equipment Building (MEB). MPF-30 is the MLNSC Neutron Scattering Experiment Hall (ER-2); MPF-622 is the adjacent MLNSC office building. MPF-15 and MPF-16 are outlying MLNSC support buildings. The PSR and its entry and exit tunnels are in MPF-8, directly under the PSR (Ring) Equipment Building (REB), MPF-28.

The Target 4 Cell and Shield are designated MPF-369. MPF-368 is a small utility building on top of MPF 369. MPF-29 is a nearby experiment building.

A number of other outlying buildings are in the area, including storage, experiment and utility sheds.

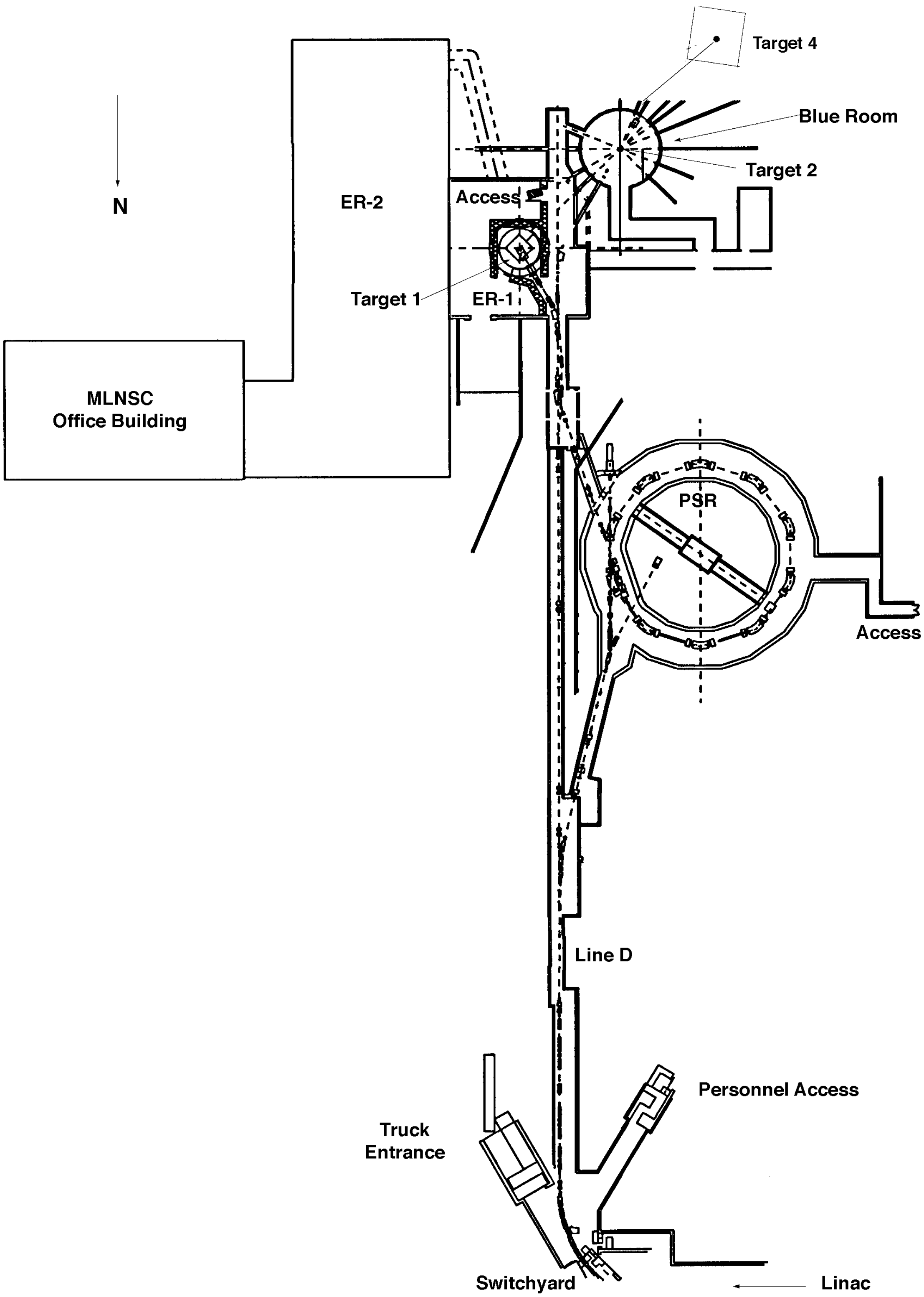

Figure 3-12. Plan view of Line D, WNR, and MLNSC.

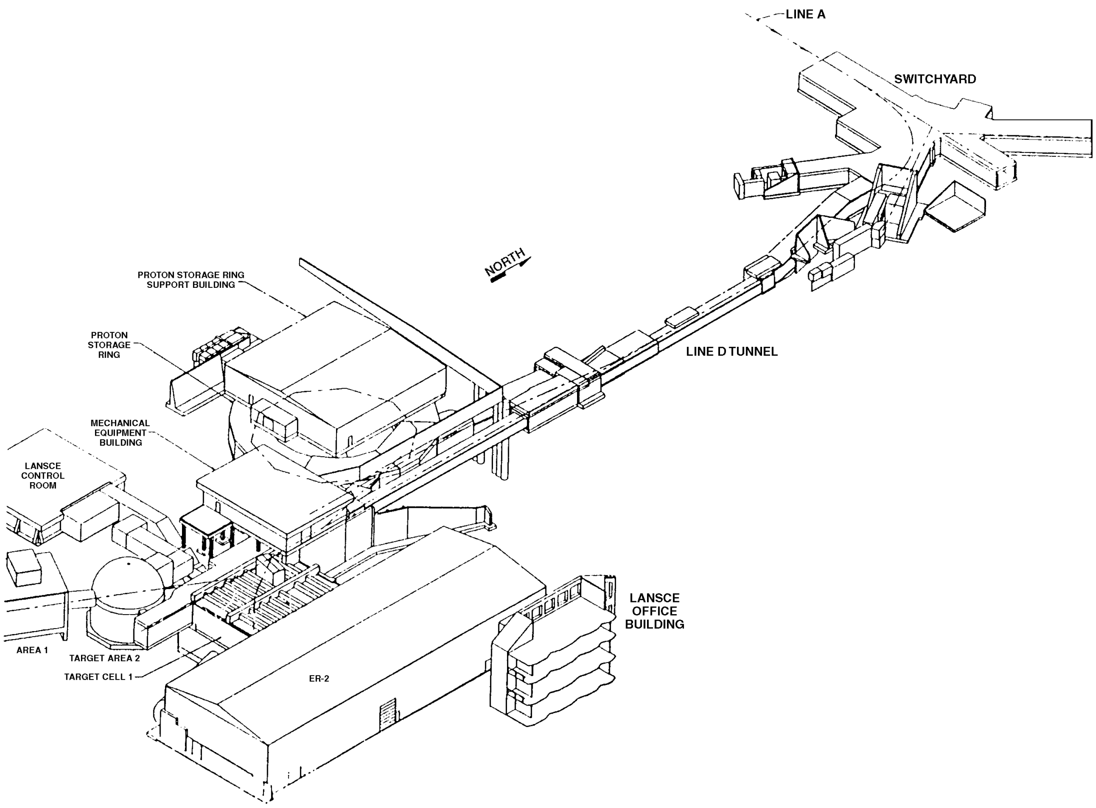

Figure 3-13. Isometric overview of Line D, WNR, PSR, and MLNSC.

3.2.4 Air Heating, Ventilation, and Air Conditioning (HVAC)

3.2.4.1 Linac HVAC System

The linac building is divided up into nine sectors. Sector J is the Injector Building, Sector A houses the 201 MHz drift-tube linac (DTL) and the transition region (TR), and Sectors B-H house the 805 MHz side-coupled linac (SCL).

3.2.4.1.1 Injector Building (Sector J)

The fresh air input for the injector building is furnished by 3 HVAC units; one with 15,215 cfm; one with 19,100 cfm; and the other with 39,330 cfm. The total HVAC intake into the injector building is 73,645 cfm. The injector building is 80’x 126’x 84’high (including the basement), for a total volume of about 850 kcf. Thus, the injector building ventilation system can deliver up to 5 building air changes per hour. The building air exhaust is primarily through roof ducts, some with fans.

3.2.4.1.2 DTL Building (Sector A)

The fresh air input for Sector A, the building housing the DTL and Transition Region, is furnished by one HVAC unit with a fan capacity of 12,000 cfm. In addition there are four heating and ventilating (HV) units, with individual intakes of 3620 cfm, 1320 cfm, 4500 cfm, and 3620 cfm for a total HV intake capacity of 13 kcfm. The total fresh air intake capability is thus 25 kcfm. The Sector A building has an approximate volume of 542 kcf (first floor is 263’ x 76’ x 17’ = 340 kcf and the second floor is about 263’ x 35’ x 22’ = 202 kcf). Thus the Sector A building ventilation system can provide up to 3 building air changes per hour. The building air exhaust is through roof ducts, some with fans, and through ducts located in the north wall.

3.2.4.1.3 SCL Building (Sectors B-H)

The Sector B-H systems are all similar. HV/HVAC fresh air input for the sector buildings enters through the south wall of each sector mechanical equipment room. Each equipment room has two HVAC units and one HV unit. In each sector, one HVAC unit is used to cool the electrical equipment and the other provides for personnel comfort. The HV unit in each sector ventilates the beam tunnel, the floor of which is 37.5’ underground. When the accelerator is operating, the tunnel HV units and exhaust fans are shut off to help maintain a stable temperature environment for equipment. Tunnel air activation is nil. High-power equipment in the beam tunnel is cooled by water. In Sectors B, D, and G pump rooms are 24.5’ below the equipment rooms, 13’ above the floor of the beam tunnel. The sector pump rooms are ventilated by the sector HV system when the accelerator is off.

Individual air capacities for the HVAC units and HV units in Sectors B-H are given in Table 3-2. In Sector B, HVAC unit AC-1B-P11 provides equipment cooling, AC-2B-P11 provides space cooling, and HV unit HV-1B-P11 ventilates the underground beam tunnel and pump room, and so forth through Sector H.

Table 3-2. The fan capacities of the Sector B-H HV/HVAC units.

Sector	AC-1B-P11, cfm	AC-2B-P11, cfm	HV-1B-P11, cfm
B	14,700	9,550	8,000
C	14,700	9,550	8,430
D	14,700	9,550	8,550
E	12,600	8,200	8,000
F	12,600	8,200	8,000
G	12,600	8,200	7,900
H	12,600	8,200	6,420

Each sector has an rf equipment room that is 200’ long × 31’ wide × 17’ high for a volume of 105 kcf. This rf equipment room is connected to the rf equipment room in the next sector by a service aisle that is about 150’ long × 8.67’ wide × 12’ high for a volume of 15.6 kcf.The 120 kcf volume in one sector building and one service aisle can receive about 10 air changes per hour from the AC-1X-P11 and AC-2X-P11 HVAC units together. The beam tunnels in each of the sectors are 13’ wide × about 350’ long (exact dimension varies) × 12’ high for a volume of about 55 kcf. The beam tunnel HV systems can provide up to 8 air changes per hour.

3.2.4.2 Line D, PSR, MLNSC, and WNR HVAC and Exhaust

The HVAC and air exhaust systems for buildings at these facilities provide ALARA dose reduction, in addition to comfort, by controlling airborne radioactivity (Hardin 1989). The HVAC in the MLNSC/WNR area is comprised of the following main components:

- Air Handling Unit 1 (AHU-1) supplies air to the Line D South Beam Channel.
- Heat and Vent Unit 2 (H&VU-2) supplies and circulates air in the PSR Tunnel.
- AHU-2 supplies air to the Blue Room (Target 2).
- AHU-3 supplies air to ER-1 and the Target 1 Service Area.
- Fan 6 exhausts air from ER-1 and the Target 1 Service Area.
- Fan 7 exhausts air through a HEPA filter and exhaust stack, FE-2. It is the main MLNSC exhaust fan, always connected to the Target 1 Service Cell (Target Cell) and South Beam Channel. By use of motorized dampers, it is also normally connected to Target 2, but can be used instead to exhaust the PSR, or ER-1 and the Service Area.
- ER-2 at MLNSC has exhaust fans from the upper levels of the experiment hall without filtration or connection to FE-2 . Experiments using radioactive materials in ER-2 are contained in tents with dedicated exhaust trunks connected to a duct to Fan 7.

3.2.4.3 Area A HVAC and Exhaust

The HVAC and air exhaust systems for buildings at these facilities provide ALARA dose reduction, in addition to comfort, by controlling airborne radioactivity. The HVAC units in Area A are listed in Table 3-3. The volume of Area A is about 1000 kcf (1 million cubic feet), so there is the capability of up to 8 building air exchanges per hour.

Table 3-3. Area A building supply fans and flow rates.
(HV = heating ventilation, FS = fan supply).

Unit	Flow Rate (cfm)
HV-1	25,097
HV-2	24,331
HV-3	15,744
HV-4	9,131
FS-6	20,029
FS-7	21,303
Total input air flow =	115,635

3.2.4.3.1 Radioactive Air

Facility air systems are managed during beam operation for environmental and ALARA considerations as well as comfort. Virtually all of the radioactive air released from LANSCE is due to Area A operation. In addition, personnel access to a few enclosed areas is controlled because of possible air activation.

3.2.4.3.1.1 Area A

The generation and control of radioactive air from beam in Area A has been characterized extensively, including the sources, composition, and controlling factors. The sources are air spaces near the A-1, A-2, and A-6 targets and beamstop through which intense primary or secondary radiation passes. Table 3-4 shows the principal isotopes.

Table 3-4. Principal radionuclides produced in air by Line A operation (1992 measurements).

Isotope	Decay Mode	Composition (%)	Half-life (min)	20-min fraction
^{16}N	e^-, γ	1.2	0.12	0
^{10}C	e^+, γ	3.9	0.32	1.5×10^{-19}
^{14}O	e^+, γ	1.6	1.18	7.9×10^{-6}
^{15}O	e^+	62.3	2.07	1.2×10^{-3}
^{13}N	e^+	12.5	10.0	0.25
^{11}C	e^+	18.2	20.5	0.51
^{41}Ar	e^-, γ	0.3	109.8	0.88

The air space around the beamline is somewhat isolated from occupiable building space by the beamline shielding and is separately ducted. Air flow is influenced by many factors, including openings for infiltration, temperature and pressure gradients, and duct operation. The strategy to control emissions involves minimizing air exchange between the building and the beam channel, ducting the beam channel air at an optimum flow rate, and using an air scrubber and a long air duct to allow radioactive decay. The last column of Table 3-2 shows the fraction left after 20 minutes of decay time. In 1995, holdup time was 100 min.

These features are invoked as necessary during operation to minimize unmonitored release, satisfy environmental requirements, and avoid excessive radiation buildup inside occupied places in Area A.

Air emissions monitoring is provided on air stack FE-3 and by spot checking on the building exterior. Only 6 kcfm of the supplied building air is removed through FE-3; all the rest leaves through cracks, openings, and doors. The air emitted through these diffuse sources is monitored for radioactivity, as discussed in Section 3.3.2.6.1. The A-East building has no ventilation equipment. It receives several thousand cfm from Area A. It is not a sealed building, so the wind provides some ventilation, which occurs through cracks in the building, around doors, and through utility passages.

3.2.4.3.1.2 Area C

If the presence of radioactive air is possible in Area C, the 39 kcfm building ventilation fan is not used and FE-3 stack suction of about 3 kcfm is maintained. This provides air emissions monitoring through FE-3. The volume of Area C is about 300 kcf; as a result, there is about one change of building air every 2 hours. When air activation is not possible, the 39 kcfm ventilation system can be used to provide fresh air (more than four air changes per hour) that has been filtered and heated, if necessary.

3.2.4.3.1.3 Switchyard, Line A, Line X, Line B, and Line C

FE-3 stack suction (about 17 kcfm) is used to vent radioactive air from the switchyard, Line A, Line X, Line B, Line C, and other areas. Normally, very little air is drawn from the switchyard (including Line X); 6 kcfm is taken from the Line A beam channel; 3 kcfm optionally is drawn from Area C (including Line C), and 8 kcfm is drawn from other areas. The radioactivity of the vented stack air is monitored as discussed in section 3.3.2.6.2 of this document, “Air Activation Detectors.”

3.2.4.3.1.4 Personnel Access

The IP Equipment Room and the PSR tunnel have ALARA-based entry requirements to account for buildup of radioactive air in these confined spaces. The requirements involve a delay between turning off beam and entry, and for PSR, use of ventilation.

3.2.5 Equipment Cooling Systems

3.2.5.1 Linac Cooling Systems

This section gives a brief description of linac cooling systems. Some of these linac cooling systems may contain low levels of contamination and are monitored as described in Section 3.3.2.6. The individual water systems are described below.

3.2.5.1.1.1 A01 Water System

The A01 water system supplies the cooling system for the 201 MHz rf power amplifiers and is located in the Sector A mechanical equipment room. Two pumps are installed in parallel; only one pump runs at a time. All pipes are copper. The heat exchanger is cooled directly by cooling tower water. An air extractor is installed on the outlet from the heat exchanger.

The deionization system consists of four series-parallel tank-type H-OH ion exchange resin beds. Deionized water from the makeup system is supplied when the pressure is low.

3.2.5.1.1.2 A02 Water System

The A02 system is similar to the A01 system and supplies cooled deionized water to the Sector A beam tunnel via copper pipes to many of the drift tube linac structures and much of the beam instrumentation. This and other water systems for the linac that have nearly direct exposure to the beam are monitored for radiation, although in general the level is near background. The system is located in the Sector A mechanical equipment room.

3.2.5.1.1.3 A03 Water System

The A03 water system supplies cooling for the 201 MHz tank walls and is located in the Sector A equipment room. Two pumps are connected in parallel; one is on at a time. Discharge filters are mounted near the pumps. All of the piping is made of iron. Rust inhibitor is the only conditioner added to the industrial water.

The double pass heat exchanger is cooled by the chilled water system.

3.2.5.1.1.4 A05 Cooling Water System

The A05 cooling water system is similar to the A03 system and supplies cold cooling water for rf amplifier component cooling, to the capacitor rooms for ignitron cooling, and to dummy rf loads that are intermittently connected. The A05 pumps are located in the Sector A mechanical equipment room.

Chilled water cools the A05 heat exchanger. A three-way temperature controlled bypass valve controls the amount of cold water from the heat exchanger which mixes with bypassed water. A pressure regulating system connects the supply and return headers. Makeup water is taken from the same water system that supplies the A03 system and the boiler. A strainer supplies a mechanical pressure regulator. The electrically actuated makeup valve opens on low system pressure. A bladder-type pressurized surge tank is used to limit makeup cycles as well as to dampen pressure oscillations.

3.2.5.1.1.5 J01 Water System

The J01 water system supplies deionized cooling water for the injector magnets and the injector transport area and is located in the injector building. The system features are similar to those of the A01 system.

3.2.5.1.1.6 SCL Water Systems

There is one cooling water cabinet for each 805 MHz rf power amplifier module (modules 14–48); all rf cooling water requirements are serviced from these cabinets. Deionized water is provided in each of seven sector buildings from pump and heat exchanger systems located in the sector building mechanical equipment rooms. The water is distributed to the water cabinets from supply and return headers running overhead through the length of the building.

The B01 water system also supplies cool water to the transition region (TR) bending magnet power supplies, to the Sector A quad magnet shunt plates, and also to the TAQL1, -2, and -3 quad magnet power supplies.

The B02, D02, and G02 water systems cool all of the 805 MHz accelerator tanks, quadrupole focusing magnets, the 121 MeV absorber and collector, and the 211 MeV beam stop. The B02 system supplies chilled water to Sectors B and C tank water systems as well as supplying chilled water to the Tank Resonance water system. The D02 system supplies chilled water to Sectors D and E tank water systems. The G02 system supplies chilled water to Sectors F, G, and H tank water systems.

The “02” supply systems are located in three pump rooms located between the beam tunnel and the equipment aisle. The supply headers are insulated and run along the north tunnel wall with the return headers. Controls are located in the respective sector facility control bin.

For each system, two pumps in parallel supply a heat exchanger. Only one pump runs at a time. Three series single-pass heat exchangers are cooled by the chilled water system. A three-way temperature-controlled bypass valve regulates chilled water to the heat exchangers to maintain “02” temperature. An air extractor with an air eliminator removes entrained air from the system.

Deionized make-up water is pressure regulated and controlled by the electric makeup valve. If the makeup valve remains energized for more than 10 seconds, a leak is assumed and the on-line 02 pump is stopped. A check valve prevents backflow. A pressurized bladder type surge tank allows for expansion and contraction of the water volume.

An on-line deionization system using ion exchanging bottles maintains water resistivity to greater than 1 Megohm. The deionization system is connected between the supply and return headers.

3.2.5.2 Cooling System for Switchyard, Beamlines and Areas A, X, B, C

3.2.5.2.1 Power Supply Cooling Systems (X01 and X09)

The X01 water system supplies cooling water to power supplies in Area A and Area A East. X01 pumps are located in the Area A Mechanical Equipment Room.

The X09 system supplies cooling water for power supplies for Lines B, C, and X; experimental equipment in Area C; and Line D power supplies. X09 pumps are located in the switchyard.

X01 and X09 systems are similar in operation. Two parallel pumps are controlled by a preferred source selector switch. If neither pump is on, a relay trips off all of the power supplies supplied by the system.

3.2.5.2.2 Beam Line Cooling Systems (X02 through X07)

Cooling systems X02–X07 supply cooling water to targets, beam stops, shielding, magnets, and other equipment in the northside experimental areas and switchyard. These systems are radioactive and the water is monitored as described in Section 3.3.2.6, Water Activation Monitoring.

Pumps and heat exchangers are located in shielded pits outside the north wall of the switchyard equipment room. The heat exchangers are cooled by cooling tower water (CTW). The heat exchanger temperature is controlled by regulating the CTW return flow rate.

Pump discharge from each pit goes to a valve gallery in the switchyard beam tunnel between Line X and Line A. The return from the valve gallery passes through a gas separator tank with an automatic vent to the HEPA (high efficiency particulate air) filtered facility exhaust system.

Three of the pump pits have surge tanks with a nitrogen blanket. Each pump system has a separate tank. Deionized water make-up maintains the surge tank level.

The valve gallery connects pump pits to pipe distribution systems. A bypass valve, between supply and return headers, controls system pressure. Tap-offs from each system go to the deionizer cave, which has a water deionization loop for each system.

All piping is stainless steel to the distribution manifolds. The manifolds under the shielding in Area A have remote controls to isolate the manifolds from the headers.

3.2.5.3 MLNSC Target/Reflector Cooling System

This system provides cooling for Line D Target 1, its reflectors, beam stop and window liners (located inside the Target 1 crypt). It was designed for 500 kW of heat removal with a flow rate of 22.7 *l*/s at a pressure of 100 psi (6.89 MPa). The machinable tungsten targets absorb 80 kW net heating at 100 μA beam delivery current. All other components cooled by this system absorb less than 20 kW total at 100 μA. Beam-off decay heating varies with operating time and is on the order of 100 W immediately after the beam is turned off.

Total system cooling water is 1000 *l*, circulated by a single 60 HP centrifugal pump through a valve gallery where it divides to cool all components. Makeup cooling water is added automatically from a deionized water makeup system. The make up interval is limited to 45 seconds before shutting the pump down. Pump “on” status is interlocked with beam delivery to Target 1. Heat is exchanged through a plate-type exchanger cooled by cooling tower water.

The pump, heat exchanger, expansion tank, and valves are in the southeast corner of the service area. The system has an air separator in the service area to remove entrained air; the air is vented into the HEPA-filtered facility exhaust system. Stainless steel pipe and components have been used except for the carbon steel air separator cannister.

Approximately 0.3 *l*/s of water is stripped out of the main flow loop. Its pressure is then reduced to 40 psi (2.76 MPa), and it is passed through demineralizer tanks that are surrounded by a shielding block wall to lower the radiation level in nearby work areas.

Water resistivity and pH are monitored on this loop.

Water samples, deionization bead samples, and area radiation surveys are periodically taken by ESH-1 to keep track of current system activity. Long-term accumulation of coolant activation products resulted in radiation levels near the end of the 1990 run cycle of approximately 30 rem/hr within the demineralizer shield block wall and 1 rem/hr in contact with certain pipe bends in the Target Cell.

Target coolant channels are instrumented to monitor the input and output temperature, flow, and pressure. Reflectors, beam stop, and window liners are monitored for temperature, flow, and pressure. Target 1 Run Permit is lost, turning off beam, if target coolant flow, ion beam window coolant flow, or crypt vacuum is lost.

All primary cooling water systems at MLNSC and PSR are within buildings having floor drains that feed into the radioactive liquid waste collection system, so that coolant spills are not released to the sanitary sewage system. Drip pans that drain directly into the floor drains are provided where leaks have been experienced to reduce floor contamination, and spills at other points are promptly flushed into the radioactive liquid waste system. All flow circuits can be purged with dry helium, forcing the water into the radioactive liquid waste tanks, reducing risk of spill and personnel exposure during maintenance. Water can also be directed to the downstream side of the target for back-flushing if necessary.

3.2.5.4 MLNSC Moderator Cooling System

This system is similar to the target/reflector system; its volume is about 200 liters. It services three chilled water moderators adjacent to Target 1. The supply from the chiller is controlled to maintain a 40°F inlet temperature. Moderator coolant activation is several orders of magnitude less than for the Target Cooling System.

3.2.5.4.1 MLNSC Liquid Hydrogen Moderator System

One of the four moderators is a liquid hydrogen moderator that presents two main concerns: handling of cryogenic liquids and of highly combustible gases. Combustible gas detectors are used to give early warning of any hydrogen leak from the system. Detection of a leak will cause all of the hydrogen to be automatically vented through a dedicated stack. This system is discussed in more detail in Section 4.4.2.1.

3.2.5.5 PSR Cooling Systems

Two deionized recirculating cooling water systems are provided for the PSR. One of these systems cools beam control components in the ring tunnel and is radiologically contaminated. The deionizing bank and heat exchanger for this system are located in a radiologically controlled area in the PSR Equipment Building. The other, non-contaminated, system cools components located in the PSR and WNR Equipment buildings only. Its deionizing bank and heat exchanger are located in an equipment room in the PSR equipment building. Make-up water is provided to both systems through a back-flow preventer. Cooling tower water is used to cool both of the above closed-loop systems.

Primary coolant leakage from the contaminated systems drains into the radioactive liquid waste system.

3.2.5.6 WNR Target 4 Cooling System

The Target 4 cooling system is located in Building MPF-368, directly above the target. This closed cooling system incorporates deionizer beds, an expansion tank, redundant pumps, and a helium purge capability. Cooling water flow is 8.5 liters/s; the temperature rise is less than a few degrees for any planned beam current or target arrangement. Purged gases are vented through a HEPA filter and stack approximately 9 m above ground level. Any coolant drainage or spillage in the utility building drains to the facility radioactive liquid waste collection system. Target 4 Run Permit is lost if target water flow, beam exit window water flow, or crypt vacuum is lost.

3.2.5.7 Line D-South Magnet Cooling System (W02)

The W02 water system provides cooling for all magnets in the Line D southside beam tunnels except the PSR. It has a primary coolant capacity of 750 liters.

The W02 system is a recirculating loop operating at a pressure of 190 psig with a flow rate of 322 liters/min. The heat exchanger for this system is cooled with the same cooling tower water system used to cool the MLNSC, PSR, and WNR cooling systems. WO2 water flows at 15 liters/minute through a set of demineralizer resin beds to maintain a resistivity of about 5 Megohm-cm in the main loop.

This system is constructed with type “K” copper tubing, bronze components, and nonconductive hoses at the magnet connections. Each magnet is plumbed with isolation valves, supply strainer, and return-flow switches.

Makeup water is added automatically from the facility deionized water supply. The makeup duration is limited to 20 s before the pump shuts off, causing the magnet power supplies to turn off, dropping Run Permit. Water lost from the system drains to the radioactive liquid waste (RLW) storage tanks.

3.2.6 Utilities

Emphasis in this section is concentrated on support systems that have an impact on safety, particularly regarding operational risks and in support of operational systems.

3.2.6.1 Water Supply

Water is supplied to all of TA-53 from a 1,000,000 gallon storage tank on a hill at the west end of the site. The water level in the tank is normally maintained at 90% of capacity.

When the level in the tank drops below 50% of capacity, an alarm is generated at the LANL Utility Control Center. Booster pumps to increase the outlet pressure to above 120 psi for fire protection purposes are activated when the system pressure drops to 22 psi and one of the deluge fire protection systems is activated.

The MPF-3 and 7 are served through a looped 8-inch main.

3.2.6.2 Sewage Treatment

Ordinary sanitary waste is collected from TA-53 buildings and is delivered through a series of lift stations and an 8-inch main sewer line to the LANL TA-46 treatment plant.

3.2.6.3 Radioactive Liquid Waste (RLW) Treatment

Potentially radioactive liquid waste (primarily cooling water) is collected from floor drains in radiologically controlled areas and delivered to two sets of RLW holding tanks.

One pair of tanks, MPF-68 and 69, capacity 4,800 gallons each, collect RLW from the accelerator, experimental areas north of La Mesita Road, and Line D North. The other pair, MPF-144 and 145, capacity ~4000 gallons each, collect RLW from the remainder of Line D, the PSR, and MLNSC and WNR target and experimental areas. RLW is retained in the holding tanks until short-half-life constituents have decayed away. The tank contents are then sampled by ESH-1 and pumped to the TA-53 RLW treatment lagoon where the water is evaporated naturally. In 1996, plans are being made for alternative RLW treatment, and the lagoon will be remediated in future years.

3.2.6.4 Electrical Supply

TA-53 obtains electric power primarily through two 115 kV overhead lines to the TA-53 substation, MPF-70. At the substation the power is transformed to 13.8 kV and distributed to facility buildings through 11 separate feeder circuits. Building MPF-2 usually obtains electric power at 13.8 kV from a separate overhead line (EA-6). However, switches allow power to be fed to the site 13.8 kV buses from the EA-6 line and vice versa. Some of the peripheral buildings around the MLNSC and WNR facilities usually obtain their electric power from yet another 13.8 kV overhead line (EA-5). Again, a switch exists to power these buildings from the site 13.8 kV bus if necessary.

3.2.7 Design Criteria Comparison

3.2.7.1 General Construction Criteria

LANSCE facilities were designed and built in numerous stages over a period of nearly 30 years, in compliance with a variety of codes and design criteria. At every stage of construction of these facilities, Laboratory engineering, architect/design engineering, and contractor management efforts were exerted to ensure comprehensive consideration and adherence to the design and structural criteria in effect at the time. Past design reviews, safety analyses, and continuing operational experience have not revealed any significant safety deficiencies.

A detailed comparison of these diverse design criteria to a relevant selection of the 563 different documents referenced in DOE Order 6430.1A, and evaluation of the impact of evolved differences, is not cost effective in terms of enhancing understanding of risk to the public or to employees. The criteria discussed here are limited to seismic, wind-loading, and fire protection considerations.

Most of the permanent buildings were designed to meet 1964 or 1967 UBC seismic Zone 2 criteria and ANSI A58.1 wind loading criteria. Beam tunnels and associated structures are very massive and have deep, stabilized foundations, sufficient to allow precise beam line alignment maintenance for the life of the facility while supporting heavy shielding and equipment loads. Flooding, missile protection, blast loadings, and sub-surface hydrostatic loadings are not applicable criteria due to site characteristics and low hazard levels. A summary of the applicable structural and fire-protection criteria at the time of facility construction along with the currently applicable criteria of DOE Order 6430.1A is shown in Tables 3-5 and 3-6. Applicable lightning criteria were contained in NFPA 78, “Lightning Protection,” now NFPA 780.

3.2.7.2 Seismic Criteria

Most LANSCE facilities were originally designed in accordance with UBC 1964 and 1967 requirements for Seismic Zone 2. The Operational Basis Earthquake used in the design of the facilities had a horizontal ground acceleration of 1.8m/s2 (0.18 g). Current seismic criteria of DOE Order 5480.28 and DOE Standard 1021 for the TA-53 location [as determined by Woodward and Clyde (1995) (Figure 3-5)] require that structures be designed for a horizontal ground acceleration of 0.22 g for a 1000-year return earthquake as shown in Figure 3-5. This difference in structural design presents no additional risk to the public or to the environment and no significant risk to workers.

3.2.7.3 Wind Loading Criteria

The probability of a tornado at this location has been estimated by a DOE study to be less than 10^{-6} per year, but high winds do occur. The current applicable wind load design criterion is given in DOE STD 1020 for Performance Category 2 (PC2, usually associated with a DOE 1027 hazard classification 3 [HC 3] designation) SSCs and is 77 mph with an importance factor of 1.07. The annual exceedance probability associated with PC 2 is 2 x 10^{-2}. The design for the worst-case structure, MPF-3 Sector M (Area A), was 25 psf.

Calculations done by Group FSS-6 in accordance with DOE STD 1020, as referenced by DOE 5480.28, indicate that this building should be designed to withstand 16.1 psf. The structural design for wind loading therefore meets current DOE criteria requirements.

Table 3-5. Facility structural criteria summary.

Facility Desig-nator	Buil-ding No.	Dw'g date	As-Built Structural Criteria		Present Structural Criteria		As-Built Design Criteria	Present Design Criteria
			Seismic	Wind	Seismic	Wind		
Line D Tunnel	MPF-7	4/73	UBC 1967 w/ Amend-ments	UBC 1967, ANSI A58.1	DOE 5480.28, DOE Std 1021	DOE 5480.28, DOE Std 1021	1972 AEC App. 6301 Gen.Design Crit..	DOE 6430.1 A
Target Area (Targets 1 & 2), Control Building	MPF-7	4/73	UBC 1967 w/ Amend-ment Zone 2	UBC 1967, ANSI A58.1	DOE 5480.28, DOE Std 1021	DOE 5480.28, DOE Std 1021	1972 AEC App. 6301 Gen.Design Crit., Conceptual Design Report ENG-2-RP-15.	DOE 6430.1 A
WNR Equipment Building	MPF-7	4/73, 10/88 Sheet Metal Addition	UBC 1967, Zone 2, 1988 for Metal Building Addition	UBC 1967, ANSI A58.1 1988 for Metal Building Addition	DOE 5480.28, DOE Std 1021	DOE 5480.28, DOE Std 1021	1972 AEC App. 6301 Gen.Design Crit., CDR ENG-2-RP-15, 1983 (Rev. 1985) GY30.1 Gen.Design Crit. for Metal Building Addition.	DOE 6430.1 A
Proton Storage Ring	MPF-8	1/82	UBC 1979 Zone 2	ANSI 58.1	DOE 5480.28, DOE Std 1021	DOE 5480.28, DOE Std 1021	1977 ERDA App. 6301, Gen.Design Crit..	DOE 6430.1 A
PSR Equipment Building	MPF-28	1/82	UBC 1979 Zone 2	ANSI 58.1	DOE 5480.28, DOE Std 1021	DOE 5480.28, DOE Std 1021	1977 ERDA App. 6301, Gen.Design Crit..	DOE 6430.1 A
Target 4	53-369, MPF-823	4/85 Target 4, 6/86 150 Beam line	UBC 1982, 1985 Sec. 2312 (i)	ANSI 58.1	DOE 5480.28, DOE Std 1021	DOE 5480.28, DOE Std 1021	12/83 DOE 6430.1 Gen.Design Crit.	DOE 6430.1 A
40 Meter Expt. Building	MPF-29	2/27, Moved 7/86	UBC 1985 Sec. 2312 (i)	ANSI A58.1	DOE 5480.28, DOE Std 1021	DOE 5480.28, DOE Std 1021	Original Building - AEC 1972 Gen.Design Crit. relocated Building DOE 6430.1 Gen.Design Crit. 12/83, Revised 11/85.	DOE 6430.1 A
Neutron Scattering Hall (ER-2)	MPF-30	1/87	UBC 1985 Sec. 2312 (i)	ANSI A58.1	DOE 5480.28, DOE Std 1021	DOE 5480.28, DOE Std 1021	DOE 6430.1 Gen.Design Crit. 12/83, Revised 11/85.	DOE 6430.1 A
All Sectors	MPF-3	Title I 8/64	UBC 1964	UBC 1964	DOE 5480.28 DOE Std 1021	DOE 5480.28 DOE Std 1021	AEC App. 6301 Gen.Design Crit. Engineering Handbook parts I–III May 1963	DOE 6430.1 A

Table 3-6. Facility design fire protection criteria summary.

Facility Designator	Building No.	Dw'g Date	As-Built Design Criteria	Present Design Criteria
Line D Tunnel, Area (Targets 1 & 2), Control Building, WNR Equipment Building	MPF-7	4/73	Industrial Fire Protection, AEC Manual App. 0552; NFPA 10 & OSHA, Portable Fire Extinguishers; NFPA 13, Sprinkler System; NFPA 24, Fire Service, Mains & Hydrants; NFPA 101, Life Safety; NFPA Pamphlet 72: Detectors and Alarms	Fire Protection, DOE 5480.7A; NFPA 10, Portable Fire Extinguishers; NFPA 13, Sprinkler System; NFPA 24, Fire Service, Mains and Hydrants; NFPA 101, Life Safety; NFPA Pamphlet 72, Detectors and Alarms
Proton Storage Ring, Ring Equipment Building	MPF-28	1/82	Industrial Fire Protection, AEC Manual App. 0552; NFPA 10 & OSHA, Portable Fire Extinguishers; NFPA 13, Sprinkler System; NFPA 24, Fire Service, Mains & Hydrants; NFPA 101, Life Safety; NFPA Pamphlet 72: Detectors and Alarms	Fire Protection, DOE 5480.7A; NFPA 10, Portable Fire Extinguishers; NFPA 13, Sprinkler System; NFPA 24, Fire Service, Mains and Hydrants; NFPA 101, Life Safety; NFPA Pamphlet 72, Detectors and Alarms
Target 4, 150 Beam line 40 Meter Experi-ment Building Neutron Scattering Hall	53-369 MPF-29 MPF-30	4/85, 6/86 2/77, Moved 7/86 1.87	NFPA 10 & OSHA, Portable Fire Extinguishers; NFPA 13, Sprinkler System; NFPA 24, Fire Service, Mains and Hydrants; Chapter VII, "Fire Protection" of DOE 5480.1A; NFPA Pamphlet 72: Detectors and Alarms	Fire Protection, DOE 5480.7A; NFPA 10, Portable Fire Extinguishers; NFPA 13, Sprinkler System; NFPA 24, Fire Service, Mains & Hydrants; NFPA Pamphlet 72, Detectors and Alarms; NFPA 101, Life Safety
Area A LANSCE Experimental Hall, Area C Experimental Hall Injector Linac Switchyard	MPF-3 Sector M MPF-3 Sector P MPF-3 Sector A, J MPF-3 Sectors B–H MPF-3 Sector S	8/64	Industrial Fire Protection, AEC Manual App. 0552; NFPA 10 & OSHA, Portable Fire Extinguishers; NFPA 13, Sprinkler System; NFPA 24, Fire Service, Mains and Hydrants; NFPA Pamphlet 72: Detectors and Alarms; NFPA 101, Life Safety	Fire Protection, DOE 5480.7A; NFPA 10, Portable Fire Extinguishers; NFPA 13, Sprinkler System; NFPA 24, Fire Service, Mains & Hydrants; NFPA Pamphlet 72, Detectors and Alarms; NFPA 101, Life Safety

3.2.7.4 Wind Loading Criteria

The probability of a tornado at this location has been estimated by a DOE study to be less than 10^{-6} per year, but high winds do occur. The current applicable wind load design criterion is given in DOE STD 1020 for Performance Category 2 (PC2, usually associated with a DOE 1027 hazard classification 3 [HC 3] designation) SSCs and is 77 mph with an importance factor of 1.07. The annual exceedance probability associated with PC 2 is 2 x 10^{-2}. The design for the worst-case structure, MPF-3 Sector M (Area A), was 25 psf.

Calculations done by Group FSS-6 in accordance with DOE STD 1020, as referenced by DOE 5480.28, indicate that this building should be designed to withstand 16.1 psf. The structural design for wind loading therefore meets current DOE criteria requirements.